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PART II.—TIME STUDIES

By

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By comparing logging and milling production costs with lumber value yields, the margins available for stumpage and profit or loss by tree and log sizes can be determined.

This note, which is the second of a series of four technical notes describing some logging and milling studies in the Southern Appalachians, is concerned only with the time analyses which are essential to a calculation of costs. It presents the results of a series of time studies made principally during the course of a logging operation on the Bent Creek Experimental Forest near Asheville, North Carolina. The study period extended from the summer of 1945 to early 1946. All operations, from felling and bucking to sawmilling, were timed and analyzed.^{1/}

The apportioning of time between working and delay classifications was accomplished through repeated observations of a whole day's activity. All intervals throughout the work day were accounted for. Lunch was eliminated as a delay since it was not properly included in the working day. Weather was eliminated from the calculation of delay time because of its extreme variation between jobs and periods of time.

^{1/} The regression equation used to determine felling and bucking time was developed by Professor F. X. Schumacher of the Duke University School of Forestry, Durham, North Carolina. The regression equation used to determine skidding time was developed by George Byram of the Southeastern Forest Experiment Station, Asheville, North Carolina.

(Weather delays were not eliminated, however, from the calculation of hourly costs.) For all operations subsequent to skidding, work and delay activities were differentiated if they were of a half-minute's duration, but for the woods operations, activities were not separated unless they were of at least two minutes' duration.

Each operation, from felling and bucking to sawmilling, is discussed separately in the following sections of this report.

Felling and Bucking

The felling and bucking study was made in a mixed hardwood stand, composed chiefly of oaks, on slopes which ranged up to 100 percent, but which averaged 30 percent. Merchantable volume before cutting averaged 5.1 M bd. ft. per acre, and three-fourths of this volume was removed in the felling operation. Time records were taken on a sample of 167 mixed hardwoods^{2/}, well distributed in diameter range from 14 inches at breast height to more than 40 inches.

Observations were taken on two 2-man crews or an occasional 3-man crew using ax and crosscut saw.^{2/} In one of the 2-man crews, one man did all of the undercutting and necessary swamping. In the second crew, tasks were more evenly divided, but the crew's production was no greater than that of the first crew. In the case of the 3-man crew, one man marked log lengths, made the tree undercuts, and swamped; the other two men used a crosscut saw.

The percentage division of total time between work and delay classifications was as follows:

	<u>Percentage of time</u>
Delays	
Rest	5.3
Tools	6.8
Miscellaneous	8.2
Work	<u>79.7</u>
Total	<u>100.0</u>

^{2/} Black oak, chestnut oak, northern red oak, scarlet oak, white oak, black gum, hickory, and red maple. Observations made for yellow-poplar (11 trees) and chestnut (17 trees) were kept separate from the mixed hardwood group.

^{3/} The 3-man crew worked only 4 days. Its relative inefficiency was revealed by the fact that time in man-hours per unit of volume was 33 percent greater than after the crew was reduced to two men.

Table 1 shows total felling and bucking time per M bd. ft. of logs, gross volume^{4/}, for mixed hardwoods. Time is shown separately by tree DBH classes for average trees as well as trees with varying numbers of logs and log lengths. Yellow-poplar and chestnut are not included in the table, but from two small samples -- 11 yellow-poplar trees and 17 chestnut trees -- some conclusions about relative felling and bucking time could be drawn. Yellow-poplar required about 15 percent less time per M bd. ft. than did the mixed hardwoods. Chestnut required about 20 percent more time than did the mixed hardwoods. The poor results for chestnut can be explained by the large number of wasted cuts -- shakes, rot, and other defects not apparent until after cutting.

Table 2 presents total felling and bucking time for mixed hardwoods by log diameter classes. Time per M bd. ft. is shown separately for 10-foot logs, 16-foot logs, and average-length logs.

^{4/}Gross volume included only the total volume of merchantable logs as measured by the Scribner Decimal C rule. Jump butts and other discarded sections of the tree trunk were not included. The minimum log considered merchantable was 10 feet long, 10 inches in diameter inside bark at the small end, and 50 percent sound.

Table 1.—Total felling and bucking time per M bd. ft., gross log scale, by tree DBH class, log length, and number of logs per tree^{1/}
(Mixed Hardwoods)

Tree DBH Class	1-log tree		2-log tree		3-log tree		Average trees
	10-ft. logs	16-ft. logs	10-ft. logs	16-ft. logs	10-ft. logs	16-ft. logs	
(Man-minutes)							
14	898	569					475
16	799	500	577	353			431
18	705	444	499	315			390
20	615	388	431	274	379	246	351
22	540	344	380	239	338	214	316
24	481	306	348	215	309	193	285
26	440	281	325	201	288	180	256
28	415	260	308	191	273	169	234
30	398	249	295	184	260	163	218
32	388	241	285	178	250	158	213
34	380	235	279	173	245	154	214
36	375	230	275	169	241	150	219
38	371	227	271	166	238	148	225
40	368	226	268	164	235	146	236
42	366	225	266	162	233	144	251
44	365	224	265	161	231	142	278

Table 2.—Total felling and bucking time per M bd. ft., gross log scale, by log diameter class and log length^{1/}
(Mixed Hardwoods)

Log diameter class	10-foot logs	16-foot logs	Average length logs
(Man-minutes)			
10	521	301	487
12	455	273	408
14	404	251	345
16	366	228	300
18	339	210	270
20	319	196	248
22	301	184	232
24	285	176	220
26	273	171	213
28	263	168	208
30	255	165	204
32	249	163	201
34	245	162	198
36	242	161	196
38	240	160	195
40	239	159	194

^{1/}Total time can be reduced to working time by dividing 1.255 into total time.

Skidding

Skidding data were obtained in the same stand of mixed hardwoods from which felling and bucking data were obtained. The study sample comprised 290 observations. Slopes ranged up to 100 percent, but averaged 30 percent. Skidding distances varied up to 1,000 feet and averaged 167 feet. Number of logs per turn ranged from one to six. Load volumes varied from less than 100 to more than 1,000 bd.ft.

Observations were made on two skidding crews, both of which included a team of horses, a teamster, occasionally a grabjack, and such swamping labor as was necessary to clear skid trails and to prepare log landings.^{5/} When a grabjack was included in the crew, his function was to hook logs, nose them, and do essential swamping in the immediate vicinity of logs. Ordinarily, the latter duties were assumed by the teamster. Time observations were recorded in terms of teamster or teamster and grabjack labor. The swamper's labor was included in the calculation of skidding costs, but his time was not included in the tables showing man-hours of labor required to skid logs.

The percentage division of time between work and delay classifications was as follows:

	<u>Percentage of time</u>
Delays	
Rest	10.4
Tools	1.2
Miscellaneous	30.1
Work	<u>58.3</u>
Total	<u>100.0</u>

Table 3 shows total skidding time per M bd. ft. of logs by log diameter classes for different assumptions of slope, distance, and log length. Table 4 is similar except that time is shown by tree diameter classes.

^{5/} The work necessary to clear trails and landings for each skidding team required only 58 percent of a swamper's full time. As a result, the swamper worked more or less independently of his skidding crew and filled in on other jobs.

Table 3.--Total skidding time per M bd. ft. of logs, gross volume, for log diameter classes by slope, distance, and log length¹

Log Diameter Class	Distance - 100 Feet					Distance - 400 Feet					Distance - 800 Feet						
	Z	E	R	O	S	L	O	P	E	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs
(Man-minutes) ²																	
10	316	189	266	663	419	563	1,125	730	962								
12	221	144	189	486	335	421	841	592	733								
14	173	117	146	391	282	340	683	510	596								
16	139	98	117	330	247	283	584	450	508								
18	117	86	100	283	223	247	515	407	446								
20	101	76	86	254	203	223	455	373	409								
22	89	68	77	232	187	206	426	349	378								
24	81	62	70	214	175	192	398	326	352								
26	74	58	65	201	165	182	374	309	336								
28	69	55	60	190	156	173	355	297	323								
30	65	52	56	180	149	165	338	285	311								
32	61	49	53	172	144	158	323	275	299								
34	57	46	50	165	139	151	309	266	287								
36	53	43	47	158	134	146	297	258	275								
38	50	41	45	151	130	141	285	251	266								
40	48	39	43	144	127	136	275	246	258								

¹/Total time can be reduced to working time by dividing 1.717 into total time.

²/ Man-minutes of teamster or grabjack time. Swamper time not included.

Table 3 (Continued).--Total skidding time per M bd. ft. of logs, gross volume, for log diameter classes by slope, distance, and log length.

Log Diameter Class	20 PERCENT SLOPE						Distance = 800 Feet		
	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs
(Man-minutes) ^{2/}									
10	335	206	282	733	486	635	1,267	859	1,102
12	232	160	203	592	395	486	965	704	859
14	185	130	158	450	343	395	802	622	721
16	155	110	130	386	300	340	695	558	622
18	130	96	112	335	275	304	622	508	561
20	113	88	100	300	254	275	558	476	515
22	100	80	90	275	237	257	515	450	481
24	91	74	82	258	223	241	481	426	455
26	86	69	77	244	213	230	460	407	430
28	81	65	72	232	206	221	446	391	426
30	77	62	68	222	199	213	433	379	412
32	73	59	65	215	194	206	421	369	398
34	69	56	62	210	189	199	409	360	385
36	65	53	59	205	184	192	397	352	373
38	62	51	57	200	179	188	385	345	362
40	59	50	53	196	174	184	373	338	352

^{1/}Total time can be reduced to working time by dividing 1.717 into total time.

^{2/}Man-minutes of teamster or teamster and grabjack time. Swamper time not included.

Table 3 (Continued).—Total skidding time per M bd. ft. of logs, gross volume, for log diameter classes by slope, distance, and log length.

Log Diameter Class	40 PERCENT SLOPE						DISTANCE - 800 FEET					
	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs
(Man-minutes) ^{2/}												
10	352	218	297	793	539	690	1,387	968	1,218	1,070	820	971
12	249	172	216	601	450	539	898	719	805	719	648	708
14	197	141	170	498	388	441	786	648	645	695	599	645
16	163	124	144	429	347	385	343	343	345	635	559	599
18	139	108	125	378	318	316	316	316	316	530	530	560
20	124	98	110	342	296	295	295	295	295	530	530	560
22	110	89	100	319	278	278	278	278	278	564	564	533
24	101	82	93	301	262	282	282	282	282	545	545	513
26	96	78	88	288	251	271	271	271	271	530	530	499
28	92	75	84	279	242	261	261	261	261	477	477	486
30	88	72	80	270	235	252	252	252	252	515	515	486
32	84	69	76	261	230	245	245	245	245	500	500	473
34	80	66	72	254	225	238	238	238	238	486	486	461
36	76	64	69	247	220	232	232	232	232	472	472	449
38	72	62	66	240	216	226	226	226	226	458	458	437
40	69	60	64	234	213	220	220	220	220	446	446	425

^{1/} Total time can be reduced to working time by dividing 1.717 into total time.

^{2/} Man-minutes of teamster or teamster and grabjack time. Swamper time not included.

Table 3 (Continued).--Total skidding time per M bd. ft. of logs, gross volume, for log diameter classes by slope, distance, and log length^{1/}

Log Diameter Class	60 PERCENT SLOPE						Average ^{2/} Slope, Distance, and Log Length	
	Distance = 100 Feet		Distance = 400 Feet		Distance = 800 Feet			
10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs
(Man-minutes) ^{3/}								
10	361	229	308	842	580	736	1,478	1,045
12	259	183	226	636	490	573	1,148	894
14	206	152	180	533	422	478	971	794
16	172	132	150	465	382	418	856	731
18	149	118	132	413	353	377	762	674
20	130	107	118	374	327	344	700	624
22	118	97	107	344	307	327	657	588
24	110	92	100	327	293	314	623	564
26	103	87	94	317	284	303	600	542
28	98	83	89	307	276	293	587	528
30	93	80	85	298	269	283	574	516
32	89	77	82	289	263	274	561	508
34	85	74	79	281	257	266	549	500
36	82	71	76	274	251	259	537	492
38	79	69	73	267	246	253	525	485
40	76	68	70	262	241	247	516	478

^{1/}Total time can be reduced to working time by dividing 1,717 into total time.

^{2/}Average-length logs for average slope of 30 percent and distance of 167 feet.

^{3/}Man-minutes of teamster or teamster and grabjack time. Swamper time not included.

Table 4.-Total skidding time per M bd. ft. of logs, gross volume, for tree diameter classes by slope, distance, and log length¹

Tree DBH Class	Z E R O S L O P E						(Man-minutes) ² /			
	10-Ft. Logs	16-Ft. Logs	Average Length Logs	Distance - 100 Feet	Distance - 400 Feet	10-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs
12	343	211	283	773	453	565	1,313	831	1,056	
14	268	165	218	582	390	476	1,016	683	831	
16	220	141	182	494	340	412	848	601	718	
18	187	124	158	429	300	361	740	536	637	
20	161	110	137	378	268	319	656	484	570	
22	143	98	120	335	244	285	584	445	515	
24	125	88	106	300	223	259	525	410	472	
26	112	79	96	271	206	240	484	381	440	
28	100	72	86	252	192	223	453	362	412	
30	91	67	78	240	180	211	429	347	391	
32	83	63	72	228	175	202	410	335	374	
34	77	60	68	220	170	194	395	328	361	
36	72	58	65	213	165	187	381	322	350	
38	68	57	62	206	161	182	373	318	342	
40	65	56	60	199	158	179	367	314	337	
42	62	55	59	193	156	177	363	311	334	
44	60	54	58	189	155	176	360	309	332	

¹/Total time can be reduced to working time by dividing 1.717 into total time.

²/Man-minutes of teamster or teamster and grabjack time. Swammer time not included.

Table 4 (Continued).--Total skidding time per M bd. ft. of logs, gross volume, for tree diameter classes by slope, distance, and log length¹

Tree DBH Class	20 PERCENT SLOPE										(Man-minutes) ² /		
	Distance - 100 Feet			Distance - 400 Feet			10-Ft. Logs			16-Ft. Logs			
	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	
12	386	227	300	824	531	616	1,391	936	1,168	1,133	795	955	
14	300	187	235	676	457	567	1,133	795	1,168	972	713	841	
16	240	158	196	573	403	496	852	651	755	852	651	755	
18	201	136	168	500	361	434	764	598	687	764	598	687	
20	172	118	146	438	328	386	692	553	625	692	553	625	
22	151	106	129	391	300	349	634	515	577	634	515	577	
24	134	96	115	354	278	321	584	486	541	584	486	541	
26	120	88	105	328	259	297	549	462	510	549	462	510	
28	110	81	96	307	247	278	524	445	488	524	445	488	
30	103	77	89	290	237	264	505	429	469	505	429	469	
32	98	73	84	276	228	256	489	419	455	489	419	455	
34	93	70	80	266	223	249	476	410	443	476	410	443	
36	88	68	77	259	218	242	467	403	435	467	403	435	
38	84	66	74	255	215	237	462	397	429	462	397	429	
40	81	65	72	252	213	234	459	392	424	459	392	424	
42	79	64	71	250	212	232	457	388	421	457	388	421	
44	78	63	70	248	211	231	457	388	421	457	388	421	

¹/ Total time can be reduced to working time by dividing 1.717 into total time.

²/ Man-minutes of teamster and grabjack time. Swamper time not included.

Table 4 (Continued).--Total skidding time per M bd. ft. of logs, gross volume, for tree diameter classes by slope, distance, and log length^{1/}

Tree DBH Class	40 PERCENT SLOPE									
	Distance = 100 Feet			Distance = 400 Feet			Distance = 800 Feet			
10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs		
(Man-minutes) ^{2/}										
12	403	244	326	915	601	730	1,494	1,020	1,202	
14	309	199	254	730	513	616	1,229	893	1,052	
16	251	173	215	618	450	534	1,083	807	927	
18	215	153	189	541	403	472	962	738	834	
20	189	137	165	476	367	421	857	685	762	
22	165	124	146	426	338	379	769	637	702	
24	148	112	130	388	314	352	707	598	652	
26	133	103	118	362	299	330	659	568	613	
28	122	96	110	342	285	314	622	546	584	
30	113	89	103	326	276	302	592	527	560	
32	108	85	98	313	268	292	575	513	543	
34	103	82	94	304	261	283	561	503	533	
36	101	80	91	297	256	276	553	495	524	
38	99	78	89	292	252	270	546	490	517	
40	98	77	88	288	249	266	541	487	512	
42	97	76	87	286	247	264	538	485	509	
44	96	75	86	285	246	262	536	484	507	

^{1/}Total time can be reduced to working time by dividing 1.717 into total time.

^{2/}Man-minutes of teamster or teamster and grabjack time. Swamper time not included.

Table 4 (Continued).--Total skidding time per M bd. ft. of logs, gross volume, for tree diameter classes by slope, distance, and log length¹

Tree DBH Class	60 PERCENT SLOPE										Average Slope, Distance, & Log Length
	Distance = 100 Feet		Distance = 400 Feet		Distance = 800 Feet		16-Ft. Logs		Average Length Logs		
10-Ft. Logs	16-Ft. Logs	Average Length Logs	10-Ft. Logs	16-Ft. Logs	Average Length Logs	Logs	Logs	Logs	Logs	Logs	Logs
(Man-minutes) ²											
12	421	252	321	1,004	635	785	1,562	1,132	1,331	412	
14	328	211	261	778	546	652	1,308	996	1,142	321	
16	264	184	225	651	481	567	1,142	901	1,015	268	
18	227	161	196	568	436	505	1,022	829	920	234	
20	196	144	172	510	398	455	932	769	846	206	
22	173	130	151	462	371	412	853	718	786	184	
24	153	118	137	422	349	385	788	670	733	167	
26	137	108	125	393	331	362	738	639	690	155	
28	127	101	115	371	318	343	699	611	658	146	
30	118	96	108	352	308	330	670	592	630	139	
32	113	93	103	340	299	318	644	576	610	132	
34	108	90	100	330	292	309	623	563	592	127	
36	105	88	97	322	285	304	608	551	577	124	
38	102	86	94	316	281	300	594	543	567	122	
40	100	84	92	311	278	297	584	536	558	120	
42	99	83	90	308	276	295	577	531	551	119	
44	98	82	89	306	275	294	572	527	546	118	

¹/Total time can be reduced to working time by dividing 1.0717 into total time.

²/Average-length logs for average slope of 30 percent and distance of 167 feet.

³/Man-minutes of teamster or teamster and grabjack time. Swamper time not included.

Loading

The study of log loading on the Bent Creek Experimental Forest was buttressed with data collected from several small operations in north Georgia. In all cases, the equipment used was similar.^{6/} The sample of logs totaled 256 and was well distributed by size classes. No attempt was made to separate species.

Observations were made on four different loading crews, each of which was comprised of two drivers with trucks and a third man, usually the woods boss, to operate the loader. Time was, therefore, based on a 3-man crew and has been expressed in terms of crew-minutes. The two truck drivers helped load each other's truck. One driver would attach the tongs, then return to the truck to help the other driver guide the suspended log to its proper position in the load.

Average truck standing time was twice the actual loading time. Only 45 minutes, including delays, were required to load each truck, but each truck had to wait while the other was loaded, thus making an average total of 90 minutes for the operation. Loading time was divided between work and delay classifications as follows:

<u>Percentage of time</u>	
Delays	
Rest	2.5
Equipment	11.5
Miscellaneous	23.4
Work	<u>62.6</u>
Total	<u>100.0</u>

Table 5 shows total loading time per M bd. ft. of logs by log size classes.

In table 6, total loading time per M bd. ft. of logs is shown for various log length classes by tree diameter classes.

^{6/} Tongs, attached to a 150-foot cable, were suspended from an A-pole frame. Power was furnished by an old automobile engine.

Table 5.--Total loading time per M bd. ft. of logs, gross volume, by log diameter and length classes^{1/}

Log Diameter Class	Log Length in Feet				Average Length Logs
	10	12	14	16	
(Crew-minutes) ^{2/}					
10	149	125	101	77	131
12	89	77	65	54	78
14	61	53	46	40	53
16	46	40	35	30	40
18	37	32	27	24	30
20	30	26	22	19	24
22	24	21	18	14	19
24	21	17	14	12	16
26	18	14	13	11	14
28	16	13	11	10	13
30	16	13	11	10	13
32	16	13	11	10	13
34	16	13	11	10	13
36	16	14	13	11	14
38	18	16	14	13	16
40	19	18	16	14	18

Table 6.--Total loading time per M bd. ft. of logs, gross volume, by tree diameter and log length classes^{1/}

Tree DBH Class	Log Length in Feet				Average Length Logs
	10	12	14	16	
(Crew-minutes) ^{2/}					
14	107	96	83	70	97
16	85	75	65	56	75
18	67	61	53	45	61
20	53	48	43	37	48
22	43	40	35	30	40
24	36	34	29	24	34
26	30	28	24	20	27
28	26	22	19	16	22
30	22	21	17	14	19
32	20	19	16	13	18
34	19	18	14	11	16
36	18	16	14	11	16
38	16	14	13	10	14
40	18	16	14	11	16
42	19	18	16	13	18
44	22	21	19	16	21

^{1/} Total time can be reduced to working time by dividing 1.597 into total time.

^{2/} A crew consists of a loader operator plus two men to hook, guide, and unhook logs.

Hauling

Sixteen truck hauling trips^{7/} were observed in this study, enough to establish the fact that no significant variation in time of haul could be related to log size. Working time varied little from one trip to the next, both in regard to total distance and to each of the four classes of road. On the other hand, there was a tendency to carry a constant volume of logs, regardless of the variation in log size. In this study, at least, time of haul per M bd. ft. could be considered constant.

Average working time and distance of haul for an average truckload of 1.5 M bd. ft. are listed in table 7.

To average working time, 19.6 percent must be added to equal total hauling time. This increase for delays, amounting to 27 minutes per round trip, was calculated as follows: rest, 1.2 minutes; equipment failure, 8.8 minutes; miscellaneous delays, 17 minutes.

Unloading

Unloading time was recorded in following through all hauling observations. The two trucks arrived at the mill together. The drivers would loosen binder chains, unload first one truck, then the other.

As in the case of hauling, no relation between time and log size could be observed. The position of logs on the load, taper, sweep, and roughness appeared to be of greater significance to the time of unloading than individual log size. For the average truckload of 1.5 M bd. ft., total elapsed time was 15 minutes. However, since the drivers unloaded only one truck at a time, an average of 30 minutes elapsed between the arrival of the trucks at the mill yard and their departure.

Delays comprised 14 minutes out of every 30 minutes. Considering each truck separately, work time for an average load took 8 minutes, loading of truck trailer on truck required 4 minutes, rest and other delays took 3 minutes.

7/

The analysis was based on two 1-1/2-ton trucks with trailers.

Table 7.--Average truck working time and distance of haul by class of road

Class of Road	Distance in Miles	Travel Time in Minutes Per Trip		
		Out	Return	Total
Truck trail	0.1	3.6	3.7	7.3
Woods road	0.9	13.2	8.9	22.1
Graded gravel	5.9	22.0	14.6	36.6
Asphalt highway	<u>11.7</u>	<u>45.2</u>	<u>26.8</u>	<u>72.0</u>
Total	<u><u>18.6</u></u>	<u><u>84.0</u></u>	<u><u>54.0</u></u>	<u><u>138.0</u></u>

Sawmilling

The sawmilling time study was made at a stationary circular mill sawing about 10 M bd. ft. of lumber per day.^{8/} Seven men were required to operate the mill^{9/} plus two men to pile lumber in the yard.

A total of 955 logs, varying in size from 10 inches to 44 inches in diameter and 10 feet to 16 feet in length, was timed at the headsaw. The log volume was 168 M bd. ft. In all, 18 hardwood species were sampled, although 5 of the samples contained less than 20 logs.^{10/} The logs came principally from the Bent Creek Experimental Forest, although basswood, beech, black birch, buckeye, black cherry, cucumber, and sugar maple came from the Big Ivy working circle of the Pisgah National Forest.

By comparing sawing time for the larger species samples, it was found that only two time groupings were necessary, one for hard hardwoods, the second for soft hardwoods.^{11/} This reduction to two species groups provided a broad basis for determining the variation of sawmilling time by log sizes -- 577 hard hardwood logs and 378 soft hardwood logs.

^{8/} The mill was a No. 7 Wheeland, stationary type, with a gang edger (3 saws), a trimmer (2 saws), a swing cut-off saw, and a small skidder for hauling logs from the yard to the deck. The power unit was a new Murphy Diesel engine of 150 h.p.

^{9/} The seven men included a sawyer, dog setter, edgerman, trimmerman, cut-off sawyer, lumber sorter, and log yardman.

^{10/} Following is the distribution of species samples taken: white ash, 4 logs; basswood, 112; beech, 9; black birch, 44; buckeye, 17; black cherry, 4; cucumber, 32; black gum, 23; hickory, 31; red maple, 60; sugar maple, 182; black oak, 15; chestnut oak, 124; northern red oak, 78; scarlet oak, 23; white oak, 65; yellow-poplar, 96; chestnut, 36.

^{11/} The hard hardwoods include white ash, beech, black birch, hickory, sugar maple, and all oaks. In the soft hardwoods group are included basswood, buckeye, chestnut, cucumber magnolia, and yellow-poplar. Black cherry, black gum, and red maple, on the basis of physical properties belong to an intermediate group, but on the basis of sawmilling time, were found to group with the soft hardwoods.

Sawmilling time was divided between work and delay classifications as follows:

	<u>Percentage of Time</u>
Delays	
Rest	2.1
Equipment	8.7
Miscellaneous	11.6
Work	<u>77.6</u>
Total	<u>100.0</u>

Table 8 shows total sawmilling time per M bd. ft. by log size classes, and table 9 gives the same information by tree diameter classes. The figures given in table 9 are based on the tree-log relationships found on the Bent Creek Experimental Forest. They may not be strictly true when applied to the species from the Big Ivy working circle, but are probably a fair approximation. In interpreting both table 8 and table 9, it will be noted that in some diameter classes time for average-length and 12-foot logs coincide. That is because the average length is 12 feet. For other diameter classes, however, average length may be either larger or smaller than 12 feet and sawmilling time varies accordingly.

Table 8.—Total sawmilling time per M bd. ft., lumber tally, for log diameter classes by species group and log length classes^{1/}

Log Diameter Class	Hard Hardwoods					Soft Hardwoods				
	Log Length in Feet					Log Length in Feet				
	10	12	14	16	Aver. Lgth	10	12	14	16	Aver. Lgth
(Crew-minutes) ^{2/}										
10	146	130	115	99	134	146	130	115	99	134
12	93	86	81	76	88	86	81	76	71	81
14	73	70	66	62	70	68	64	61	57	64
16	63	59	57	54	59	58	54	50	46	54
18	57	54	52	49	54	50	48	44	40	46
20	52	50	49	46	50	46	44	40	36	43
22	48	46	46	44	46	43	40	37	33	39
24	46	45	44	43	45	40	37	35	32	36
26	45	44	43	41	44	39	36	33	31	35
28	45	45	45	44	45	39	37	35	32	36
30	46	46	46	46	46	40	39	36	33	37
32	48	48	48	49	48	41	40	39	36	40
34	52	52	53	54	52	43	41	41	40	41
36	55	58	59	61	58	45	44	44	44	44
38	59	62	64	67	63	48	48	48	49	48
40	64	68	73	73	70	52	53	54	55	53

Table 9.—Total sawmilling time per M bd. ft., lumber tally, for tree diameter classes by species group and log length classes^{1/}

Tree DBH Class	Hard Hardwoods					Soft Hardwoods				
	Log Length in Feet					Log Length in Feet				
	10	12	14	16	Aver. Lgth	10	12	14	16	Aver. Lgth
(Crew-minutes) ^{2/}										
14	112	107	102	97	107	106	98	90	84	98
16	93	88	84	80	88	86	80	73	68	80
18	79	75	71	67	75	72	67	62	58	67
20	67	64	62	59	64	62	58	54	50	58
22	60	58	55	54	58	55	52	49	46	52
24	56	54	52	50	54	51	48	45	53 43	48
26	53	50	49	47	50	48	44	41	39	44
28	50	48	46	45	48	45	41	39	36	41
30	49	46	45	44	46	44	40	37	35	40
32	48	45	44	43	45	43	40	37	35	40
34	46	44	43	41	44	42	39	36	33	39
36	46	44	43	41	44	41	39	36	33	39
38	46	44	43	41	44	41	39	36	33	39
40	48	45	44	43	45	43	40	37	35	40
42	49	46	45	44	46	44	41	39	36	41
44	52	49	48	46	49	46	44	41	39	44

^{1/} Total time can be reduced to working time by dividing 1.29 into total time.

^{2/} A crew consists of seven men plus two men to pile lumber.

